Title

Biomass Combustion and Co-firing

Mário Costa

Departamento de Engenharia Mecânica
Instituto Superior Técnico
Avenida Rovisco Pais, 1049-001 Lisboa, Portugal

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Presentation overview

- Current status of biomass combustion
- Biomass combustion fundamentals
- Combustion technologies (full-scale)
- Co-firing
- Summary and concluding remarks

Current status of biomass combustion

There are a lot of combustible biomass available

Pine wood chips (as fired)

Current status of biomass combustion

Harvesting and pre-treatment is available

Current status of biomass combustion

Biomass combustion (modern plus traditional combustion) represents around 15% of world energy consumption…

… and some up to 90% in some developing countries!

About 2.5 billion people worldwide depend on biomass combustion through the use of relatively simple combustion devices

Current status of biomass combustion

European policies that stimulate biomass combustion

Reduce greenhouse gas emissions (Kyoto Protocol)

Increasing the share of renewable energy sources

National policies (e.g., co-firing)

Biomass combustion fundamentals

Combustion steps are well established

Heating and drying

Devolatilisation

Volatiles Combustion

Char Combustion

Sub-models related to NO_x, ash and metals

Biomass combustion fundamentals

Devolatilisation

The rate of devolatilisation, for both coal and biomass, is still a matter of some contention and a number of approaches have been used to model it.

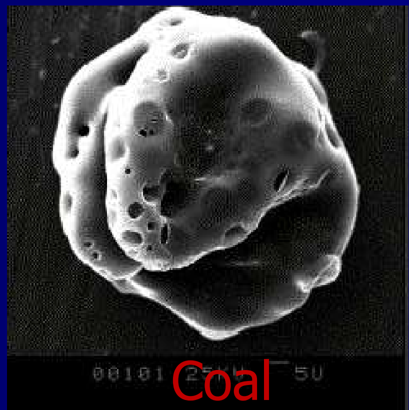
The simplest models employ global kinetics, where Arrhenius expressions are used to correlate rates of weight loss with temperature.

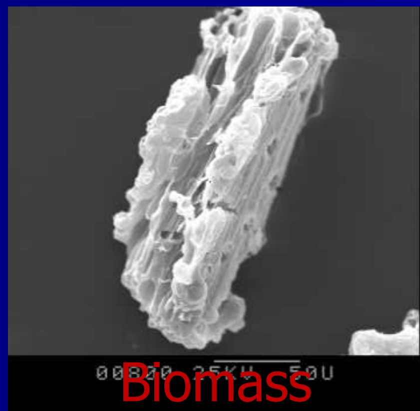
Biomass combustion fundamentals

Biomass char oxidation

Little information at high temperatures

Irregular shaped char particles are a problem

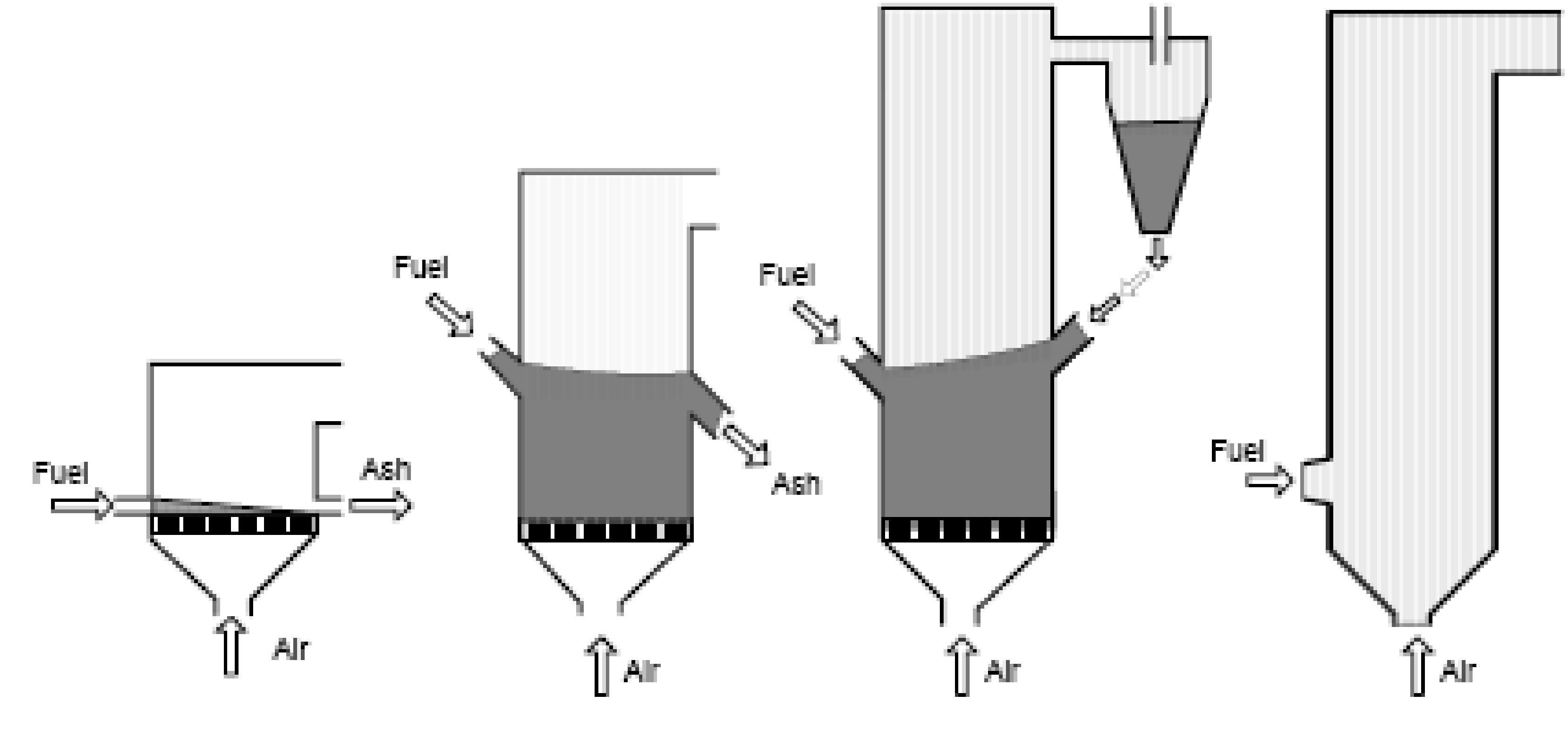




Catalytic effects are small at high temperature

Rate of oxidation of O-containing char different to that of coal char… but only small amount of char produced

Combustion technologies (full-scale)

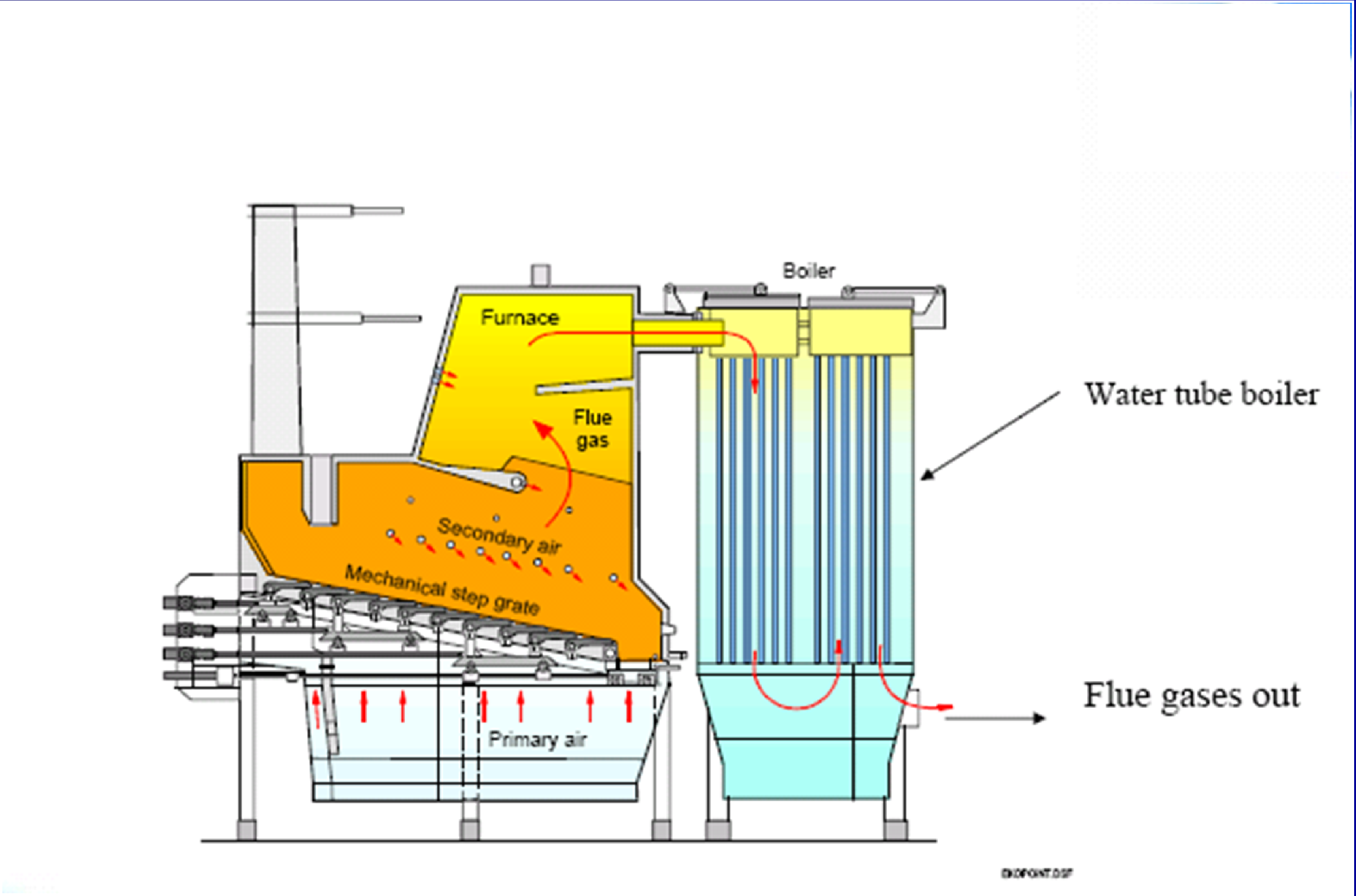


Fixed bed furnace (grate furnace)	Bubbling fluidized bed furnace	Circulating fluidized bed furnace	Pulverized fuel furnace

Domestic woodstoves and domestic pellet boilers are not treated here!

Combustion technologies (full-scale)

Fixed bed furnace (grate furnace)



Combustion technologies (full-scale)

Fixed bed furnace (grate furnace)

Diagram of the combustion process in fixed fuel beds

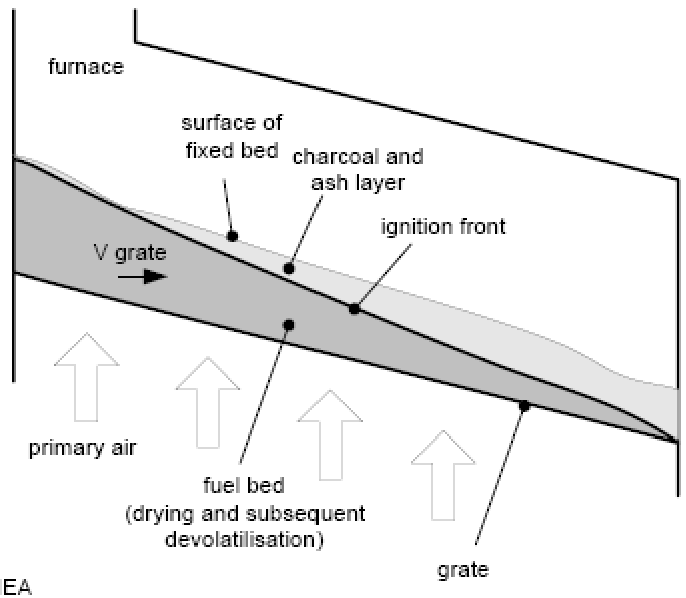


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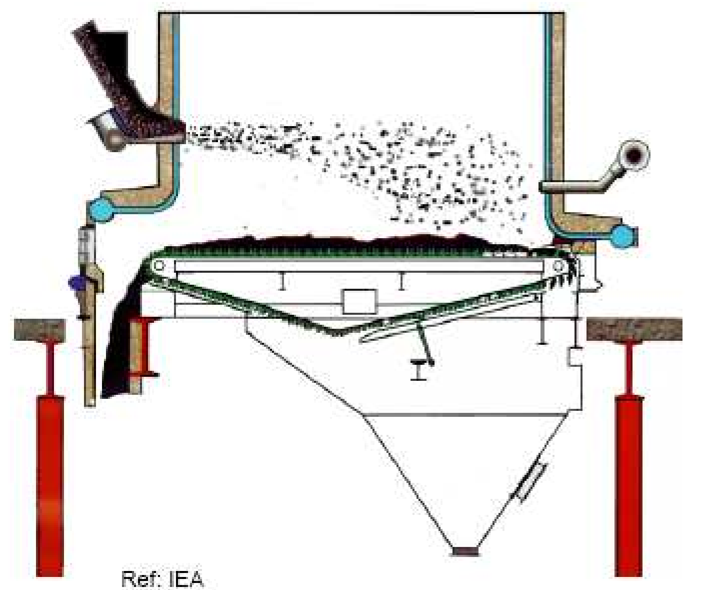
Diagram of a travelling grate furnace fed by spreader-stokers



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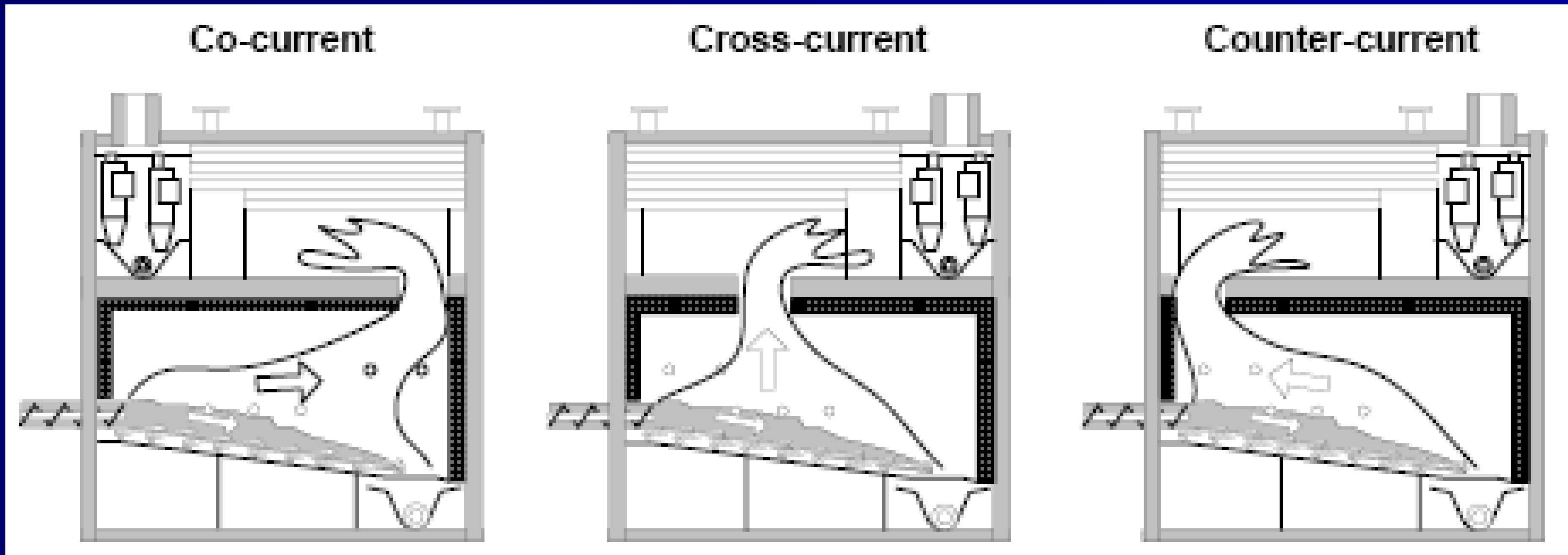
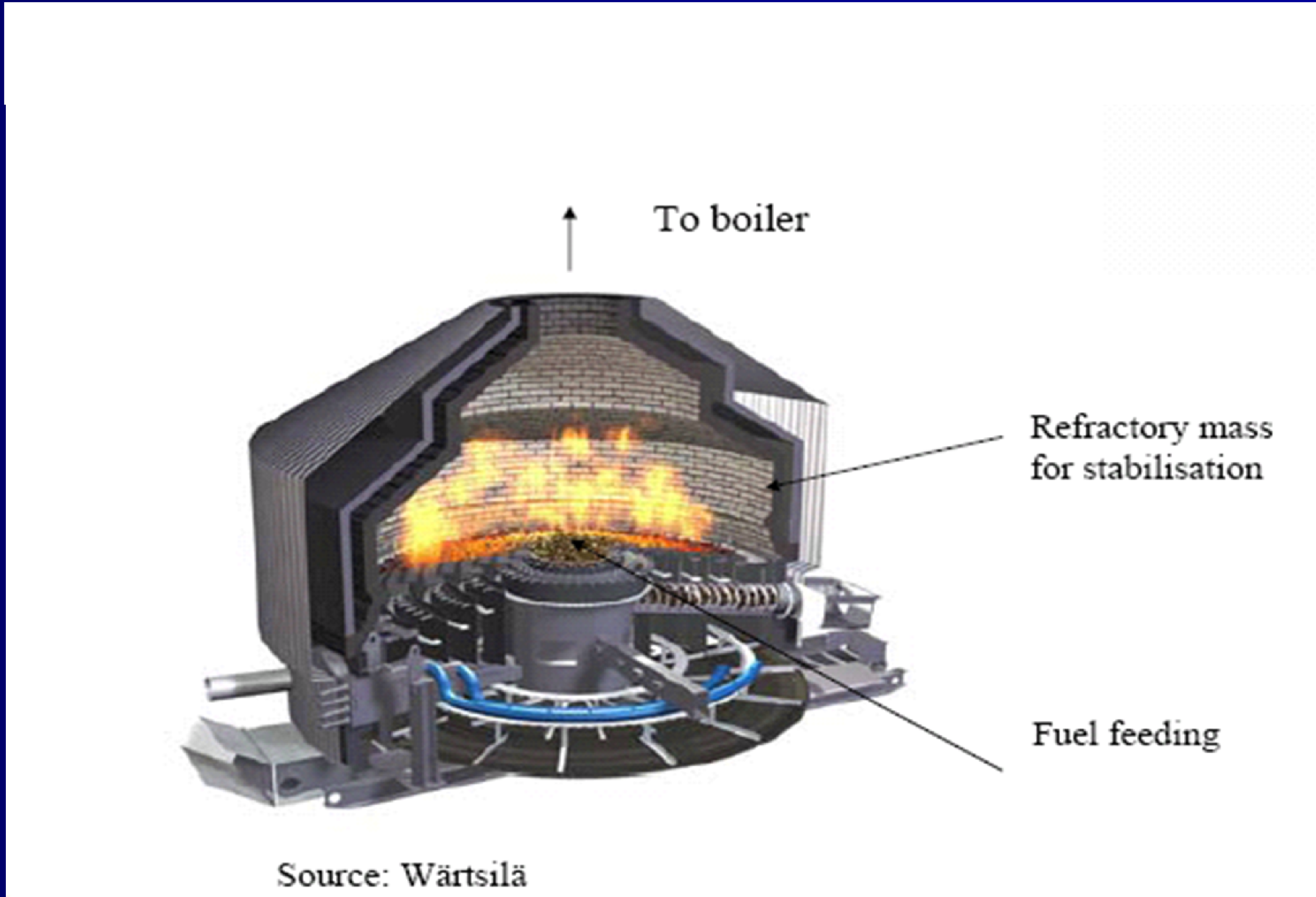
Combustion technologies (full-scale)

Fixed bed furnace (grate furnace)



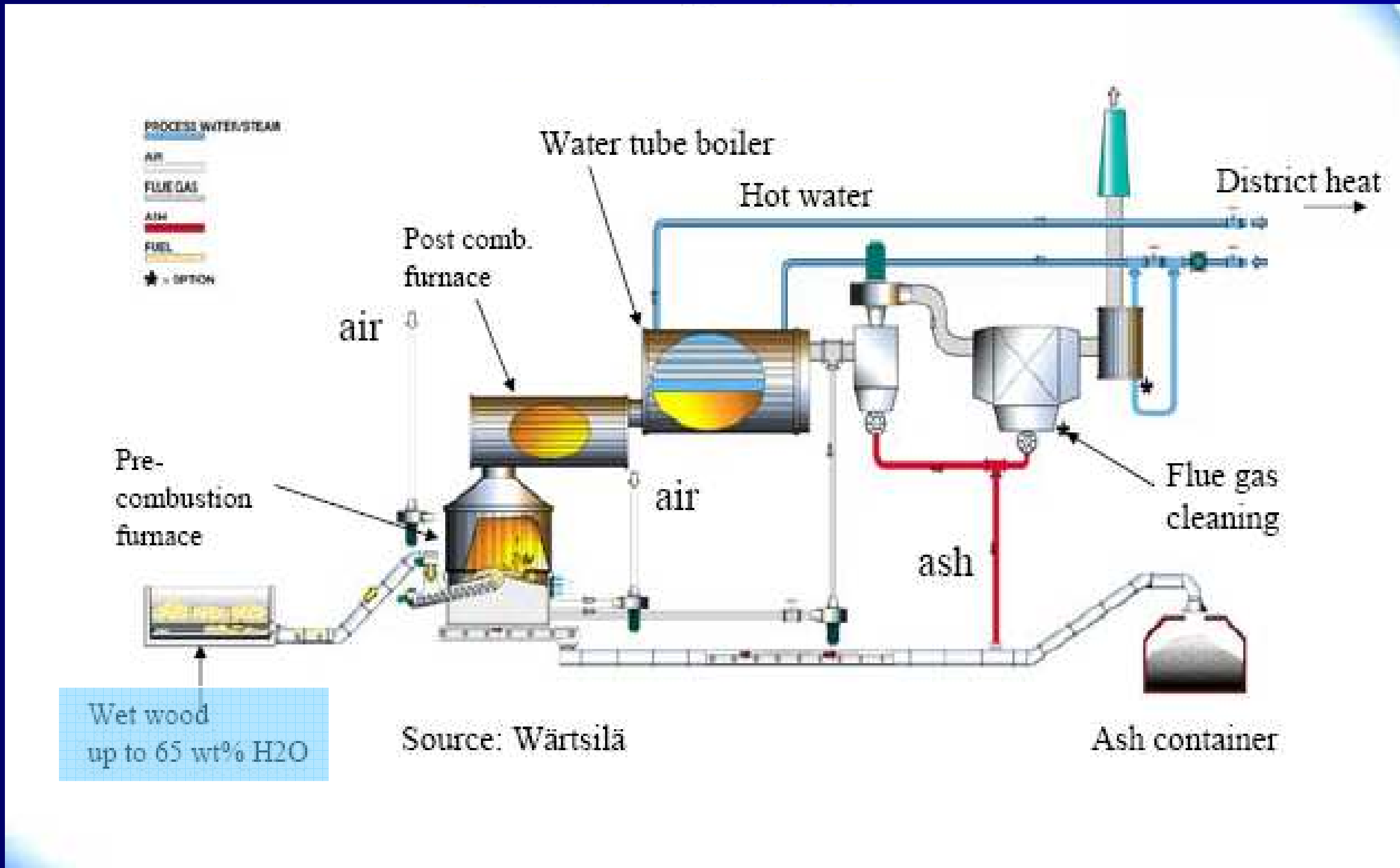
Combustion technologies (large-scale)

Fixed bed furnace (grate furnace)



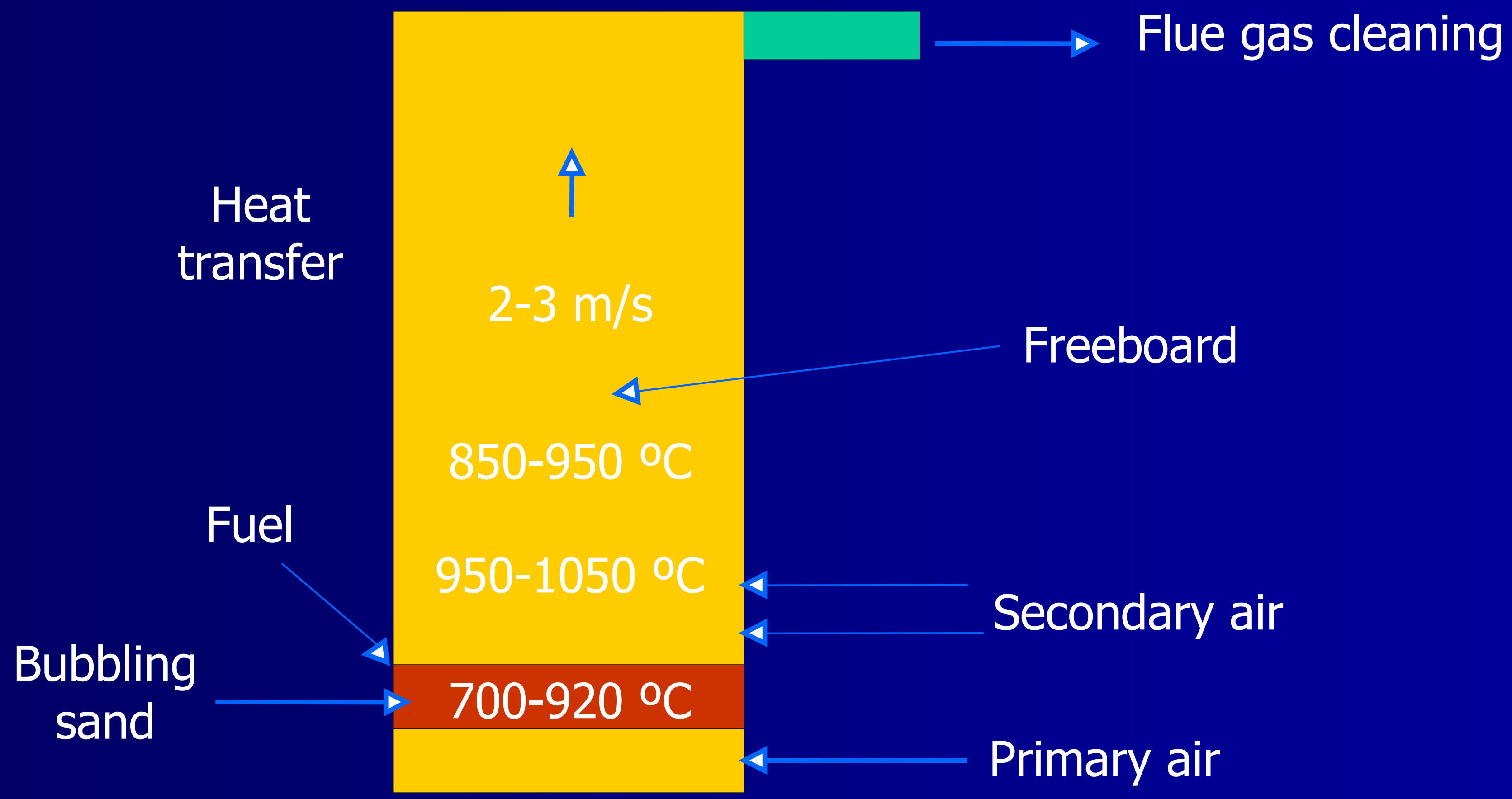
Combustion technologies (large-scale)

Fixed bed furnace (grate furnace)



Combustion technologies (full-scale)

Bubbling fluidized bed furnace



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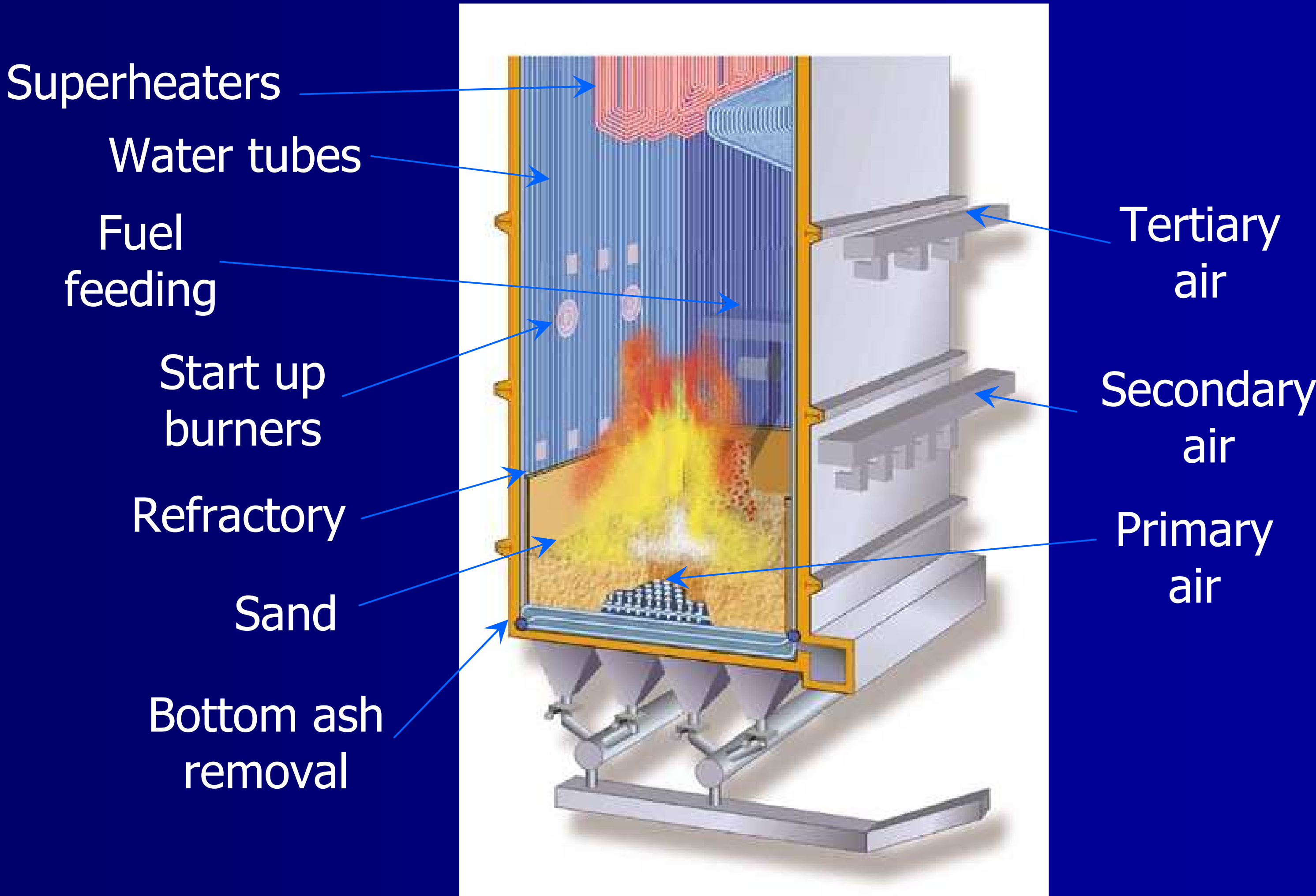
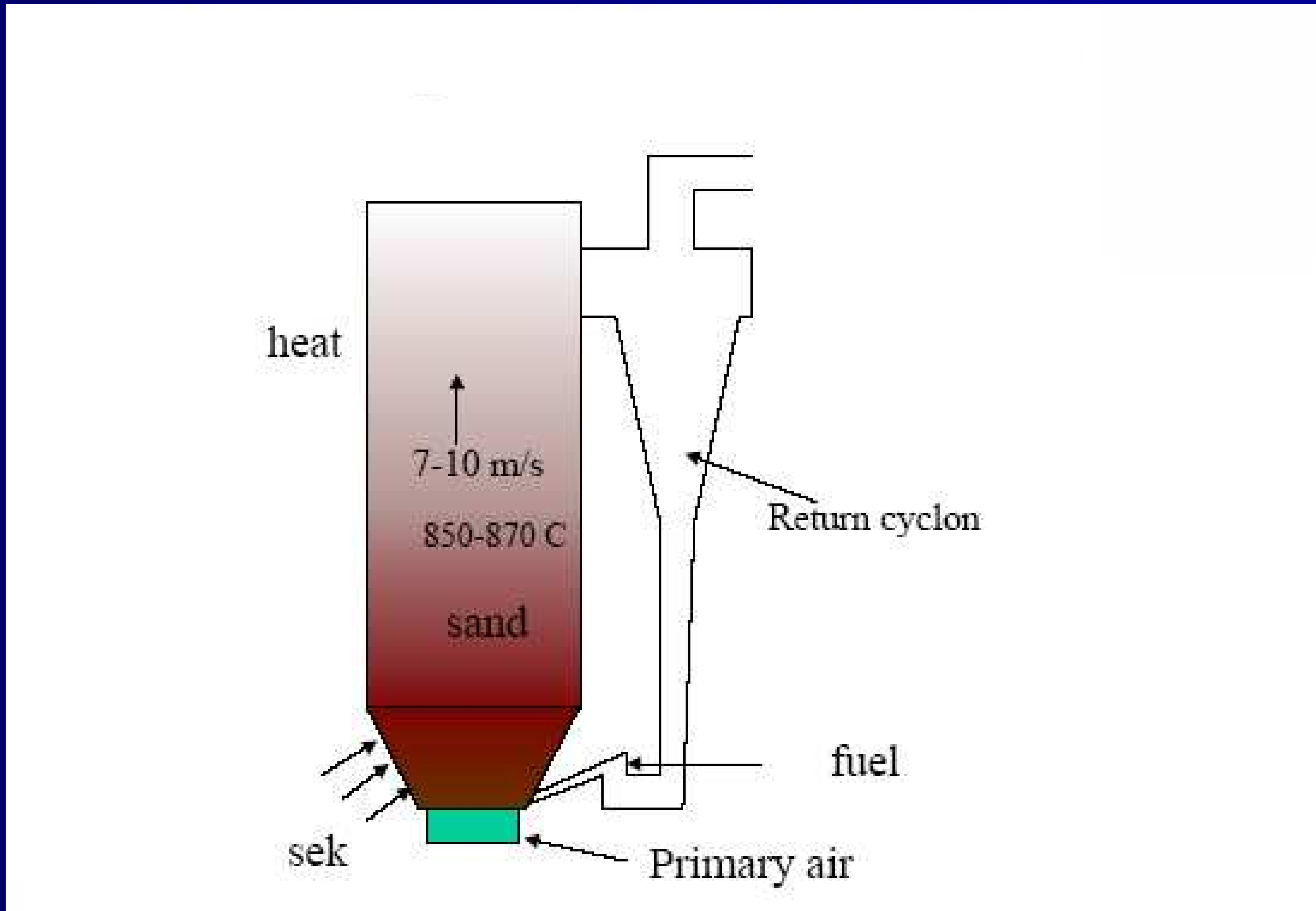


Combustion technologies (full-scale)

Circulating fluidized bed furnace



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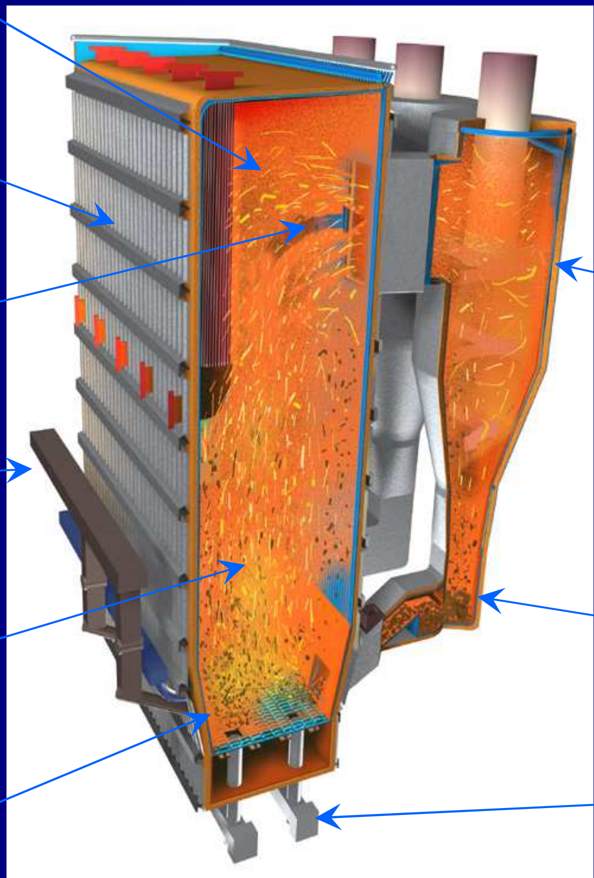
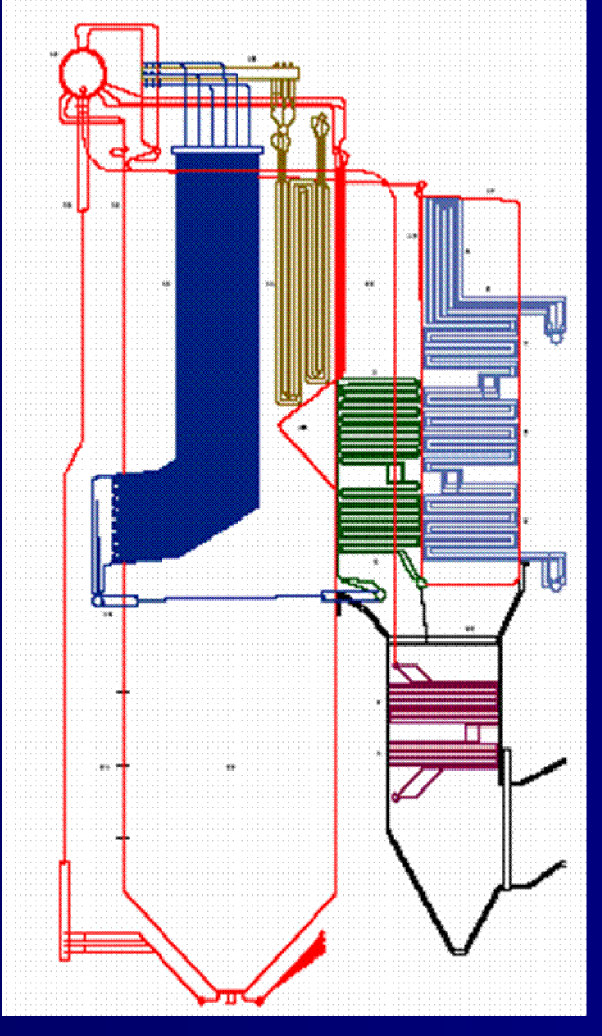


Combustion technologies (full-scale)

Pulverized fuel furnace



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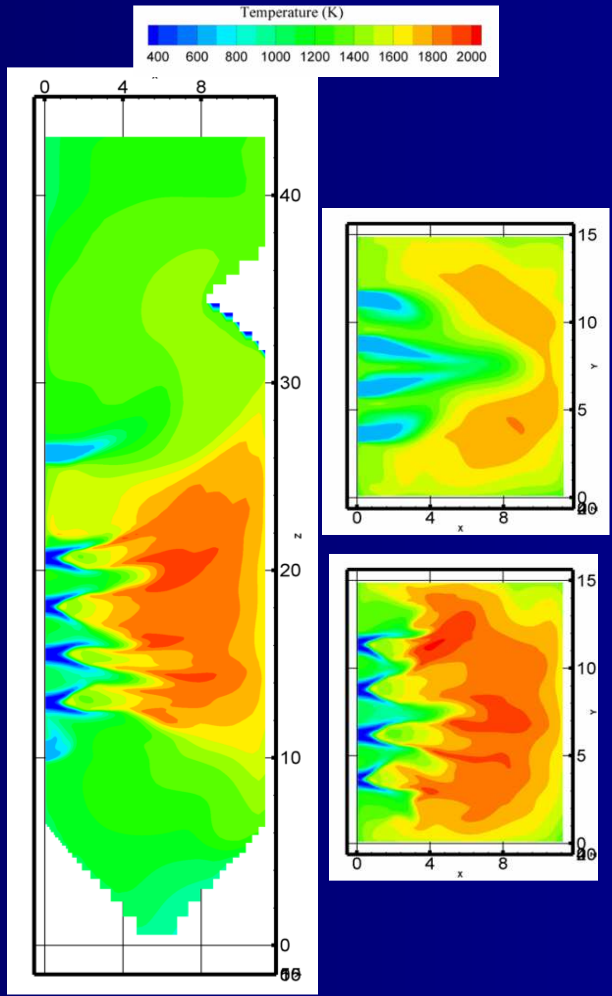
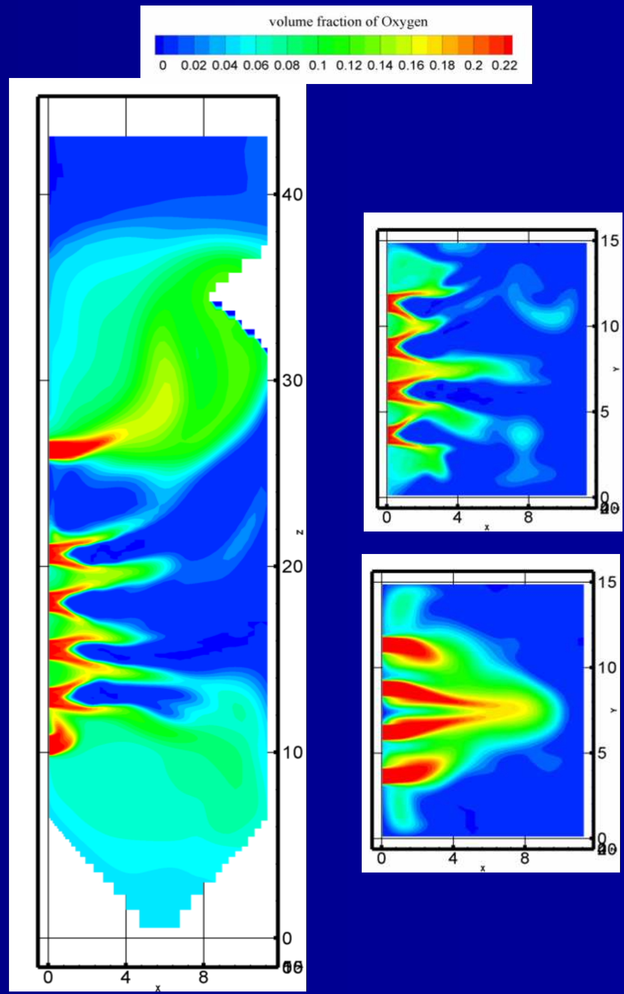




Combustion technologies (full-scale)

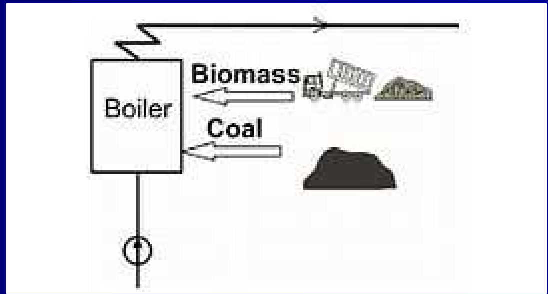
Comparison between some characteristics of the combustion processes in grate, fluidized bed and pulverized fuel furnaces

Characteristic	Combustion technology		
	Pulverized	Grate	Fluidized bed
Combustion efficiency (%)	99	70-90	90-99
Global thermal efficiency (%)	35-45	25-35	40-55
Excess air (%)	15-50	20-40	10-25
Particle size (mm)	< 0.5	12-20	8
Operating temperature (ºC)	1400-1700	1400-1700	800-1000
NO_x emissions	High	High	Low
SO_x capture(%)	–	–	80-90

Co-firing

The use of biomass co-firing

Direct co-firing in coal fired power plants is used by power stations in EU and USA



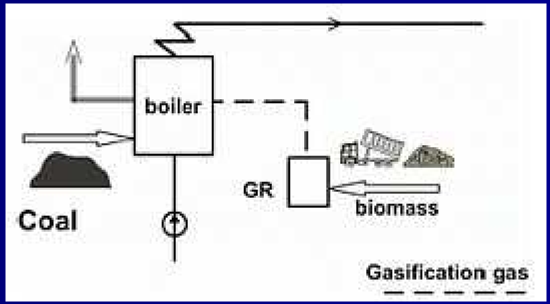
Demonstrated successfully in more than 130 installations worldwide, for most combinations of fuel and boiler type

Most use about 10% of biomass (energy basis) but can readily burn up to 25% thermal

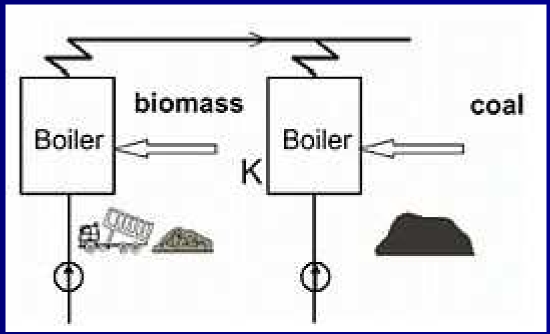
Co-firing

The use of biomass co-firing

Indirect co-firing with pre-gasification or other thermal pretreatment

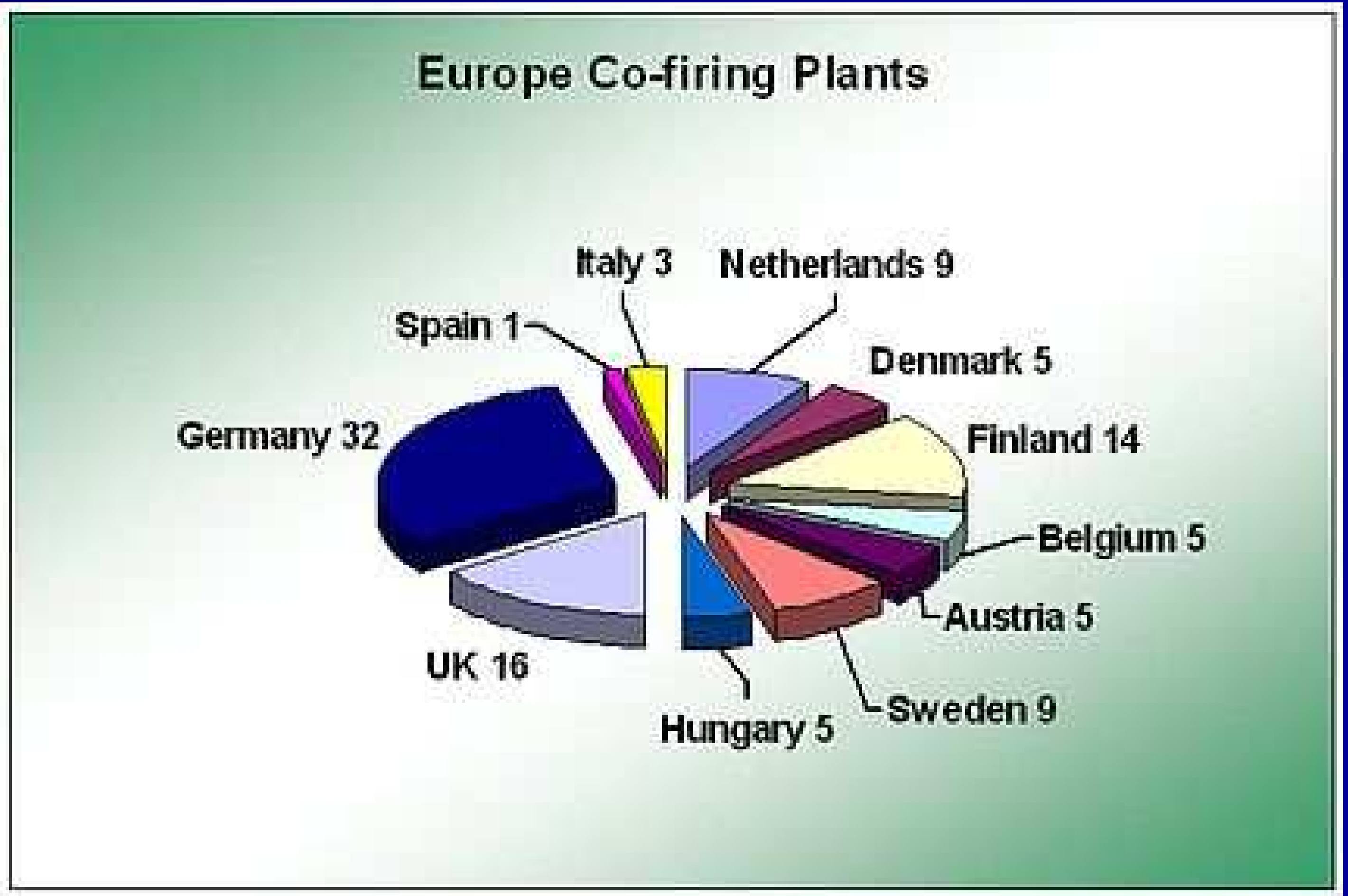


Parallel co-firing



Co-firing

Europe direct co-firing plants

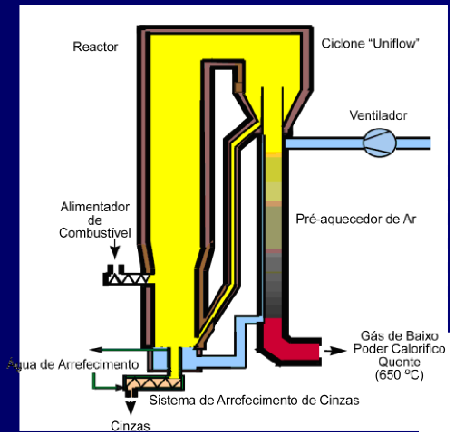


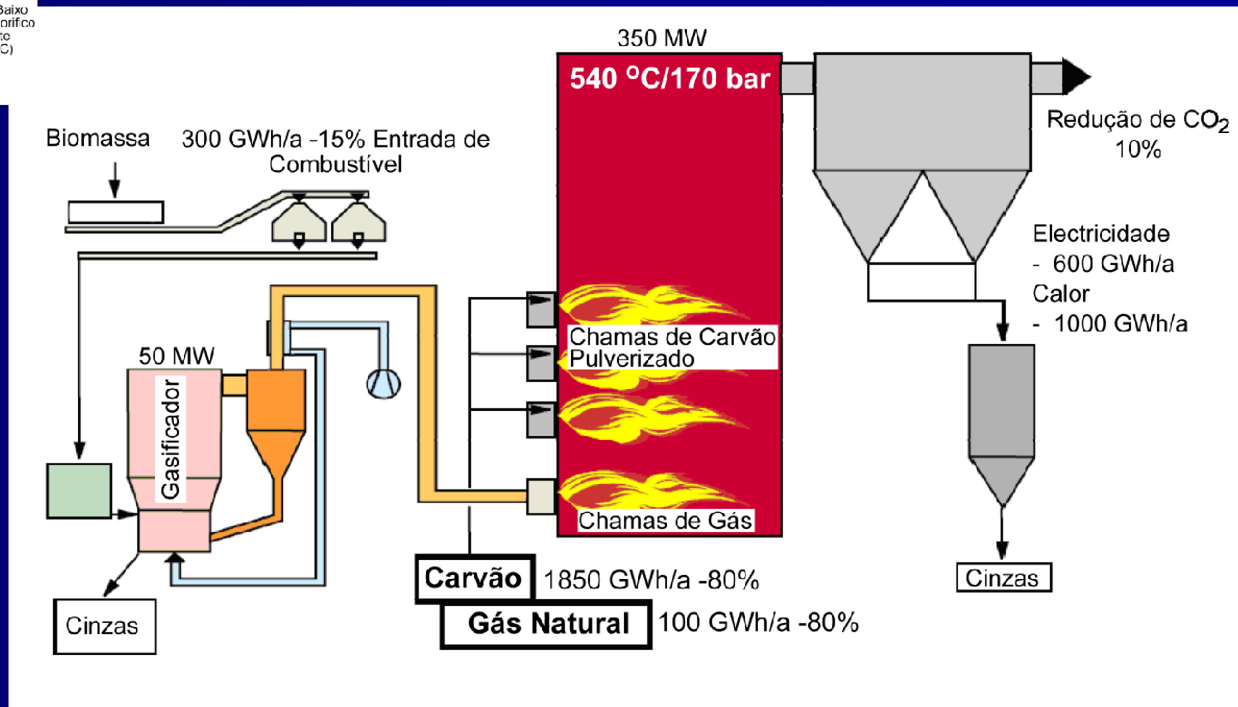
Combustion technologies (full-scale)

Direct co-firing: Fiddlers' Ferry Power Station (UK) uses 20% of biomass

Combustion technologies (full-scale)

Indirect co-firing: Lahti, Finland





Co-firing

Advantages of co-firing

Co-firing can be undertaken with existing power plants, and thus has high power generation efficiency

Short term implementation on large scale; if well-managed, technical risks are low

It is attractive in terms of the capital investment requirement and generation cost.

It can increase the amount of renewable energy and thereby reduce the CO_2 emissions

Co-firing

Advantages of co-firing

Almost any biomass material can be used (e.g., wood, olive and palm oil waste, cereal and straw. Thus it is attractive in terms of security of supply

Usually, biomass fuels present low levels of sulphur, nitrogen and toxic metals. Thus reduction of pollutant emissions (e.g., NO_x, SO_x) is achieved

Co-firing

Disadvantages of co-firing

Biomass is a poor fuel: it contains O_2 and a substantial amount of moisture

Contains potassium: it can cause corrosion

Biomass can be expensive: it depends on subsidies at present

May not be sustainable

Co-firing

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Co-firing

Fuel handling issues

Biomass can be milled with coal, or it can be milled in advance and added to the coal, or burned in a separate burner

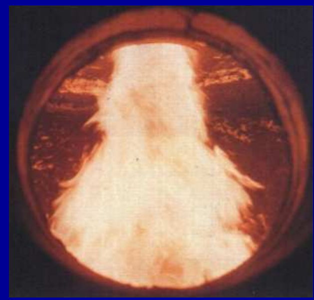
There can be problems with grinding and drying certain fuels, particularly fibrous materials such as wood

These can be overcome by using large scale drying techniques

Other hazards are from dust and from spontaneous ignition

Co-firing

Pulverized fuel IST furnace



Co-firing

Biomass fuels compared with coal

Quantity	Coal	Pine Sawdust	Pine Shells	Pine Branches	Olive Stones
Proximate Analysis (wt%)					
Moisture	2.3	13.6	13.92	12.5	9.4
Volatiles	29.1	72.7	58.9	63.7	57.8
Fixed Carbon	64.77	13.5	25.88	21.2	19.7
Ash	4.7	0.2	1.30	2.6	13.1
Ultimate Analysis (wt%)					
Carbon	82.83	46.48	47.78	46.65	43.22
Hydrogen	4.5	6.85	4.3	6.25	5.56
Nitrogen	1.81	0	0.31	0.94	1.86
Sulfur	1.13	0	0	0	0
Oxygen	2.73	32.87	32.39	31.06	26.86
High Heating Value (MJ/kg)	32.83	18.13	18.82	18.32	17.54
Low Heating Value (MJ/kg)	31.80	16.68	17.05	17.00	16.36

Co-firing

Pulverized fuel IST furnace: co-combustion of biomass with natural gas

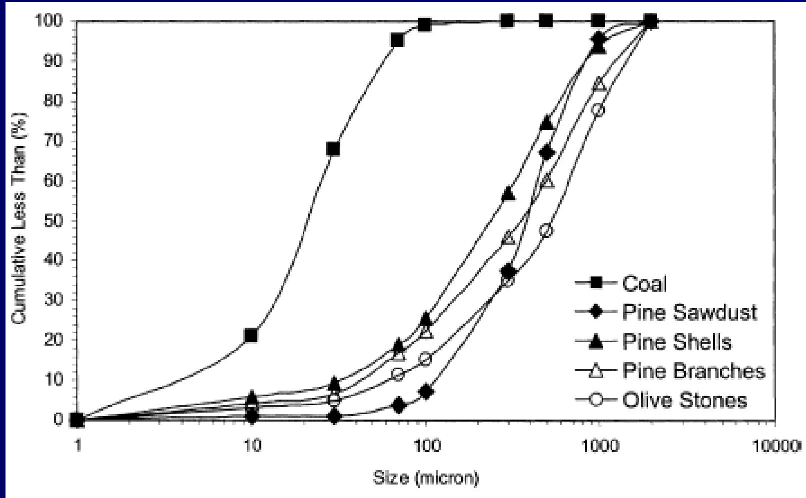


Figure 4. Particle size distribution for solid fuels.

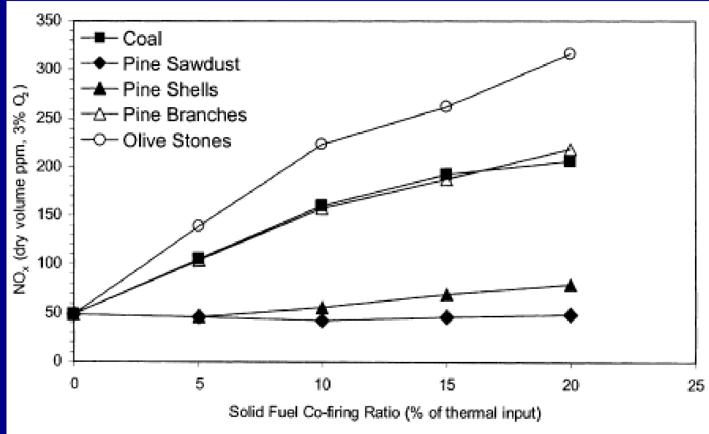


Figure 7. Influence of the solid-fuel cofiring ratio on the flue-gas NO_x.

CASACA, C. and COSTA, M. (2003). Co-combustion of biomass in a natural gas fired furnace. Combustion Science and Technology, **175**, 1953-1977.

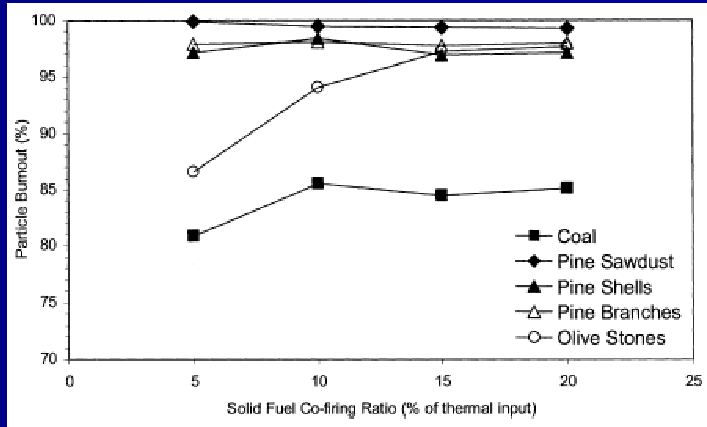


Figure 8. Influence of the solid-fuel cofiring ratio on the particle burnout.

Co-firing

Information available in the literature on

- **Emissions**
- **Ash deposition**
  It may be a problem, need for investigation
- **Carbon conversion**
  Biomass fuels in coal power plants show that large, wet or high-density biomass particles may undergo incomplete combustion
- **Chlorine-based corrosion**
  High-temperature corrosion of superheaters is of great concern when burning high-chlorine or high-alkali fuels
- **Fly ash utilization**
  Current standards preclude the use of fly ash as a concrete additive from any source other than coal

Summary and concluding remarks

Worldwide, combustion is by far the most commonly applied bioenergy technology

Full- and large-scale biomass co-firing is one of the most efficient and cost-effective approaches to generate electricity from renewable sources.

Co-firing can make a significant contribution to the reduction of the CO_2 emissions

A number of coal power plants have plans to increase (or initiate) the biomass co-firing capabilities for long term operation

There are however issues in relation to supply and legislation … ***but without a doubt …***

Summary and concluding remarks

there is there is future for …

… Biomass Combustion and Co-firing!!!